

grade photographic paper, having a plurality of microdots **90** thereon typically arranged in a predetermined array. It facilitates understanding of the present invention to note that a yellow microdot will cause the blue code value at the location of the microdot to be lower than the blue code values surrounding the microdot.

Referring to FIG. 3, a flowchart of a software program of the present invention implemented by the computer system **10** is illustrated. It is instructive to note that the flowchart illustrates a preferred embodiment of a software program contained on either the floppy disk **61**, compact disc **57** or programmed into the microprocessor-based unit **20**, although other computer-readable storage medium may also be used.

After the software program is initiated **S2**, the program sequentially processes each pixel in the image through the below described process. At the pixel of interest, the blue code value is considered first **S4**. The blue code value at location in the image at column p and row l is denoted by $V_b(p, l)$. First, the median blue code value $M_b(p, l)$ of pixels in a box of size $w \times w$ that is centered at this location is calculated **S6** for permitting comparison of the median blue code value with the pixel of interest, as will be described hereinbelow in detail.

It should be understood that, if location p, l contains a microdot, $M_b(p, l)$ is an estimate of the blue code value of the image (scene) that was printed on the document at location p, l . The appropriate width w of the box is dependent on the size of the microdots in the copy-restricted document and the resolution at which it was scanned. For example, for the current copyrighted paper that is manufactured by the Eastman "KODAK" Company, if the scanner resolution is 200 dpi, then use $w=5$. Those skilled in the art will be able to determine other suitable sizes depending on their application.

If the value $M_b(p, l)$ is not greater **S8** than the parameter Dark, preferably a code value of 50, then the scene printed on the paper at that location has a high enough yellow density to mask the yellow dot. In this case, the pixel at p, l is not altered and the next pixel is considered. The value Dark is dependent on the relationship between image code values and print density and is usually set by examination of the processed image.

If the value $M_b(p, l)$ is greater than Dark, the next step is to calculate a correction term **S10** for the blue code value C_b that will be used in overall corrections (Eqs. 4) if this location is determined by the below-described criteria to contain a microdot. The correction term C_b is calculated using the equation:

$$C_b = M_b(p, l) - V_b(p, l) \quad \text{Eq. 1}$$

The affect of the yellow microdot is to lower the blue code value below that of the scene; therefore if a yellow microdot is located at position p, l , then C_b should be a positive number. If C_b is smaller than Min_b **S12**, a small positive number typically 15, then there is either no yellow dot at this location or the blue code value of the scene is close enough to that of the dot that it is not necessary to modify the code value of the pixel.

One the other hand, if C_b is greater than Max_b **S12**, then the lowering of the blue code value relative to that of the scene is uncharacteristically large. Based on this, the program assumes that the pixel is not a yellow dot, and the program goes to the next pixel. The appropriate value of Max_b is highly dependent on the copyrighted paper and the scanner used to produce the digital image. Typically a value of 100 is used.

The purpose of the next series of steps is to verify that the pixel is indeed a yellow dot. Next, the red code value of the pixel is considered. The median red code value $M_r(p, l)$ of pixels in a box of size $w \times w$ that is centered at pixel p, l is calculated **S14**. The correction term for the red code value C_r uses the equation:

$$C_r = M_r(p, l) - V_r(p, l) \quad \text{Eq. 2}$$

where V_r is the red code value of the pixel of interest at location p, l . The affect of the yellow dot on the red code value of the pixel should be negligible. Therefore, if the absolute value of C_r is larger than a positive number Max_r , typically 40, then the feature in the image that is responsible for a high value of C_b is not yellow in color **S16**. It is concluded that a yellow dot does not exist at this location, the pixel's code values are not changed, and the next pixel is considered.

Similarly, the correction term for the green band C_g is calculated **S18** using the equation:

$$C_g = M_g(p, l) - V_g(p, l) \quad \text{Eq. 3}$$

where V_g is the green code value of the pixel of interest. The yellow microdots are normally not pure yellow in color and usually have some magenta density. For this reason, if a yellow dot is located at position p, l , C_g may not be zero. Yet, if the absolute value of C_g is larger than the positive number Max_g **S20** typically 100 then it is uncharacteristically large for a yellow dot. The program concludes that the pixel is not a yellow dot, the pixel's code values remain unchanged, and the next pixel is considered.

If all of the above conditions are satisfied the pixel's red, blue, and green code values are modified **S22** according to the equations:

$$V'_r(p, l) = V_r(p, l) + C_r, \quad V'_g(p, l) = V_g(p, l) + C_g, \quad V'_b(p, l) = V_b(p, l) + C_b \quad \text{Eq. 4}$$

If a yellow dot is located at position p, l tests show that this is very effective in removing the appearance of a yellow dot from the image at that location.

The program checks **S24** whether this is the last pixel. If it is not, the program continues to the next pixel. If it is, the user may either exit **S28** the program or start the above-described process on another image **S26**.

Using this procedure, only a small fraction of the pixels in the image are modified, most of which correspond to yellow dots in the image. For this reason the removal of the yellow dots from the image by this method has a negligible affect on the quality of the scene.

The invention has been described with reference to a preferred embodiment. However, it will be appreciated that variations and modifications can be effected by a person of ordinary skill in the art without departing from the scope of the invention.

Parts List:

10 computer system

20 microprocessor-based unit

30 display

40 keyboard

50 mouse

52 selector

55 CD-ROM

56 printer

57 compact disc

60 scanner